Indian Journal of Engineering

ANALYSIS

ISSN 2319 – 7757 EISSN 2319 –7765

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Publication History
Received: 09 June 2016
Accepted: 06 July 2016
Published: 1 October 2016

Citation
Karthika S, Shenbagavalli R. Detection of Exudates in the Color Retinal images Based on Morphological Techniques. *Indian Journal of Engineering*, 2016, 13(34), 577-582

Detection of Exudates in the Color Retinal images Based on Morphological Techniques

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Abstract: Diabetic Retinopathy (DR) is one of the complications resulted from prolonged diabetic conditions usually affected after ten to fifteen years of having diabetes. It causes damage to the tiny blood vessels inside the retina. This blood vessel will leak blood and fluid on the retina, forming lesions such as micro aneurysms, hemorrhages, exudates. This research work focuses one of the causes of diabetic retinopathy called exudates. Exudates look like tiny yellow patches on the retina. Various existing research works to detect the exudates are surveyed in this thesis and an automatic system is proposed to detect the exudates on the retinal image. This project is discussed about the morphological operations such as Dilation, Erosion, Opening, Closing and Gradient to extract the exudates. And also done the comparison between each of these methods to identify which one is suitable for extracting the exudates from the color retinal image based on the features like entropy, kurtosis, standard deviation, and mean.

Keywords: Diabetic retinopathy, Morphological operations, Detection of Exudates, Image Processing.

1. Introduction

1.1. Medical Image Processing:

Medical image processing is the technique and process used to create images of the human body for clinical purposes or medical science. Although imaging of removed organs and tissues can be performed for medical reasons, such procedures are not usually referred to as medical imaging, but rather are a part of pathology.

(Mahendran *et al*, 2014) has shown an automated method which detects the diabetic retinopathy through identifying exudates by Morphological process in color fundus retinal images and then segments the severity of the lesions. In this method, the severity level of the disease was achieved by Cascade Neural Network classifier. (Ali *et al*, 2013) has suggested that a novel statistical atlas-based segmentation method for exudates. Firstly, warped the test fundus image on the atlas coordinate and then a distance map is obtained with the mean atlas image. The Post-processing schemes are introduced for final segmentation of the exudates. The method is also compared to few most other segmented methods. The proposed framework implements conventional morphological operations such as dilation, erosion, opening, closing and gradient. The features such as entropy, kurtosis, standard deviation and mean are extracted from each of these methods to identify the given input image are affected or unaffected by the exudates.

1.2 Dilation

It is the process of adding a pixel at object boundary based on structuring element. It is defined as a maximum value in the window. The image after dilation will be brighter or increase in intensity. It expands the image objects by changing pixels with value of "0" to "1".

Dilation operation can be applied by using the formula,

$$\{[(I \bullet Se) \circ Se] \bullet Se\} \oplus Se - \{[(I \bullet Se) \circ Se] \bullet Se\} \quad \ldots\ldots\ldots (1)$$

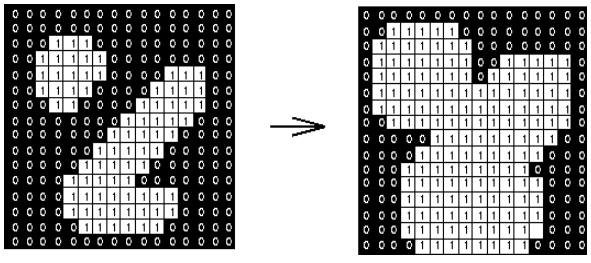

Figure 1: Dilation Operation

1.2.1 Procedure for Dilation

Step 1: Get the defect-free image and defective image.

Step 2: Resize the input images into 128 x 128 dimensions.

Step 3: Convert the input images into grayscale image.

Step 4: Closing operator is applied on input image.

Step 5: Opening operator is applied on the step 2.

Step 6: Again closing operator is applied on the step 3.

Step 7: Dilate the closed image with the same structuring element.

Step 8: Finally, subtracted the closed image from dilated image.

1.3. Erosion

Erosion is the inverse of dilation. It removes the pixel from the object boundary depending on the structuring element. Erosion is used to shrink the images by changing the pixels with the value of "1" to "0". The erosion operation is pictorially represented in Figure 1. Erosion operation can be applied using the formula:

$$\{[(I \bullet Se) \circ Se] \bullet Se\} \ominus Se + \{[(I \bullet Se) \circ Se] \bullet Se\} \quad \text{… … … (2)}$$

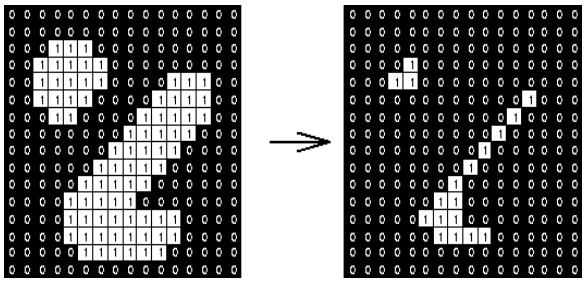

Figure 2: Erosion Operation

1.3.1 Procedure for Erosion

Step 1: Get the defect-free image and defective image.

Step 2: Closing operator is applied on input image.

Step 3: Opening operator is applied on the step 2.

Step 4: Again closing operator is applied on the step 3.

Step 5: Erode the closed image with the same structuring element.

Step 6: Finally, eroded image is added with the closed image.

1.4. Opening:

Opening is morphological operations which are based on dilation and erosion.

1.4.1 Procedure for Opening

Step 1: Get the defect-free image and defective image.

Step 2: Applied imopen() function to the input images.

Step 3: Finally, obtained the defective part of the retinal images.

1.5 Closing

Closing is morphological operations which are based on dilation and erosion.

1.5.1 Procedure for closing

Step 1: Get the defect-free image and defective image.

Step 2: Applied imclose() function to the input images.

Step 3: Finally, obtained the defective part of the retinal images.

1.6 Gradient:

1.6.1 Procedure for Gradient:

Step 1: Apply the dilation operation to the given binary image.

D1=imdilate (img,se) … … … **(3)**

Step 2: Then apply the erosion operation to the given binary image.

E1=imerode (img,se) … … … **(4)**

Step 3: Finally, subtracted the eroded image from the dilated image.

Gradient=D1-E1… … … **(5)**

2. Experimental evaluation & result analysis

In order to analyze the performance of the proposed frame work, the developed and implementation frame work for different test configuration and parameters. The following section explains the details and it evaluation.

Various images were utilized to identify the effectiveness of the method. The proposed defect detection is implemented in MATLAB 7.6.0. Some retinal images are taken to detect exudates defects. The exudates defects are detected by using various methods such as dilation, erosion, opening, closing and gradient.

Figure 1: Reference image

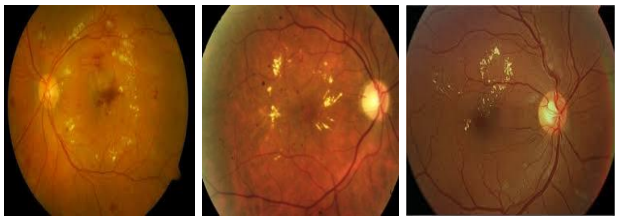

Figure 2: Retinal image with exudates

Result Analysis using various method:

Figure 3 shows the implementation of dilation operation on the three defective retinal images.

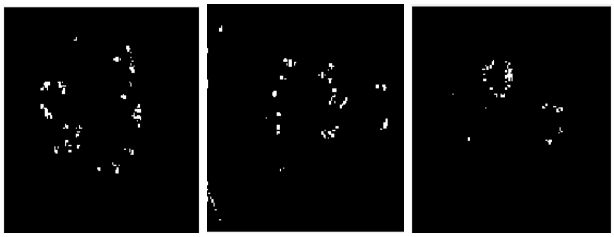

Figure 3: Dilation

Figure 4 shows the implementation of erosion operation on the three defective retinal images.

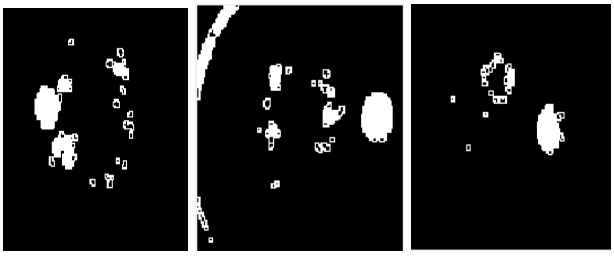

Figure 4: Erosion

Figure 5 shows the implementation of opening operation on the three defective retinal images.

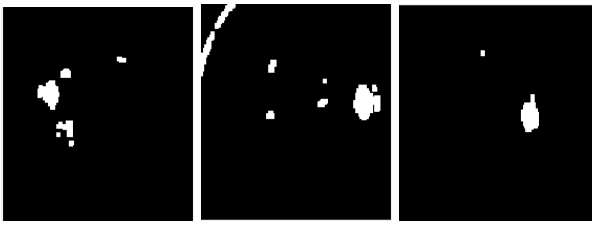

Figure 5: Opening

Figure 6 shows the implementation of closing operation on the three defective retinal images.

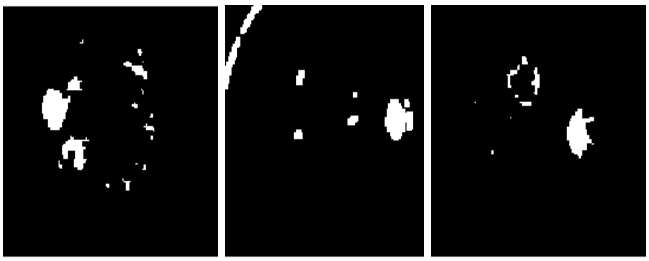

Figure 6: Closing

Figure 7 shows the implementation of gradient operation on the three defective retinal images.

Figure 7: Gradient

Features Analysis:

Table 1: Features and Formula

Features	***Formula***
Entropy	$-\sum p \log_2 p$
Kurtosis	Kurtosis(a)
Standard deviation	$\sqrt{\sum_{i=0}^{N-1}\sum_{j=0}^{N-1} pi,j(i-\mu_1)^2}$

Mean	$\sum_{i=0}^{N-1}\sum_{j=0}^{N-1} ipi,j$

Table 2 shows the average value of both reference images and affected images based on dilation method.

Table 2: Dilation method

Features	Entropy	Kurtosis	Standard deviation	Mean	Average value
Reference image 1	0.0693	1.8661	0.0907	0.0083	0.5086
Reference image 2	0.0407	1.3763	0.0661	0.0044	0.371875
Affected Image 3	0.1558	6.7867	0.1384	0.0013	1.77055
Affected Image 4	0.2773	10.5688	0.1983	0.0098	2.76355

Table 3 shows the average value of both reference images and affected images based on erosion method.

Table 3: Erosion method

Features	Entropy	Kurtosis	Standard deviation	Mean	Average value
Reference image 1	0.3102	8.6234	0.2466	0.0913	2.317875
Reference image 2	0.1206	2.5721	0.1332	0.0164	0.710575
Affected Image 3	0.3265	7.5578	0.2488	0.0586	2.047925
Affected Image 4	0.2166	6.7243	0.1883	0.0342	1.79085

Table 4 shows the average value of both reference images and affected images based on opening method.

Table 4: Opening method

Features	Entropy	Kurtosis	Standard deviation	Mean	Average value
Reference image 1	0.1856	14.8928	0.1657	0.0283	3.8181
Reference image 2	0.0727	1.8822	0.0933	0.0088	0.51425
Affected Image 3	0.1381	2.7543	0.138	0.0194	0.76245
Affected Image 4	0.0928	2.973	0.1082	0.0118	0.79645

Table 5 shows the average value of both reference images and affected images based on closing method.

Table 5: Closing method

Features	Entropy	Kurtosis	Standard deviation	Mean	Average value
Reference image 1	0.2408	8.5415	0.1952	0.0397	2.2543
Reference image 2	0.0861	1.8866	0.1034	0.0108	0.521725
Affected Image 3	0.2099	6.9927	0.179	0.0331	1.853675
Affected Image 4	0.1398	5.1997	0.139	0.0197	1.37455

Table 6 shows the average value of both reference images and affected images based on gradient method.

Table 6: Gradient method

Features	Entropy	Kurtosis	Standard deviation	Mean	Average value
Reference image 1	0.2123	6.5477	0.1803	0.0336	1.743475
Reference image 2	0.0861	2.1527	0.1034	0.0108	0.58825
Affected Image 3	0.291	5.9707	0.2202	0.0511	1.63325
Affected Image 4	0.1875	5.004	0.1668	0.0286	1.346725

According to all the above tables, the average value of dilation method have the range of 0 indicates that the given image is not affected by exudates and the range 1 indicates that the given image is affected by exudates. Among all the method, dilation method is considered to be the best method to extract exudates from the color

retinal images based on the calculated average value of features such as entropy, kurtosis, standard deviation and mean.

3. Conclusion:

In the color retinal images, proposed method is discussed about an automated extraction of exudates based on morphological techniques such as dilation, erosion, opening, closing and gradient. The project concluded that the dilation method is suitable for the detection of exudates in the color retinal images.

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